

Optimising vehicle fleet routing

Local search techniques are known to be efficient at solving such problems - especially large problems. The CBLS engine of Oskar supports the modular specification of routing problems by assembling problem elements (such as objective functions, strong and weak constraints, time windows, traffic jams, SLA as shown in Figure 2). On the other hand, it provides a rich domain specific language for working out powerful search procedures combining a rich set of neighbourhoods (e.g. insertPoint, onePointMove, threeOpt) in a declarative style using movement, acceptor and meta-heuristic operators (e.g. tabu

search, simulated annealing). This not only results in very efficient search procedures expressed at the logistics domain level but also reduces development time and facilitates maintenance when a problem evolves.

Links:

[L1] <http://oscarlib.bitbucket.org>

[L2] <http://www.simqri.com>

[L3] <http://tango-project.eu>

References:

[1] Laurent Michel Pascal Van Hentenryck. Constraint-based Local Search. MIT Press, 2009

[2] Renaud De Landtsheer et al., A Discrete Event Simulation Approach for Quantifying Risks in Manufacturing Processes, Int. Conf. on Operations Research and Enterprise Systems, February 2016

[3] Renaud De Landtsheer et al., Combining Neighborhoods into Local Search Strategies, 11th MetaHeuristics International Conference, June 2015

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Integrated Resource Planning in Maintenance Logistics

by Ahmad Al Hanbali, Sajjad Rahimi-Ghahroodi, and Henk Zijm

The MLOG (Optimal Exploitation of Resources in Maintenance Logistics) project, executed jointly by the University of Twente and the University of Qatar, focuses on an integrated planning of resources needed for asset maintenance.

In many Western countries, maintenance and overhaul of capital assets constitute some 15 % of their GDP. Smart sensor and data gathering techniques, as well as advanced decision support systems, are exploited to design integrated logistics support (ILS) systems. In the MLOG project we focus on an integrated planning of resources needed for asset maintenance rather than the piecemeal approach usually considered in the literature and in practice. The goal is to minimize overall resource investments subject to agreed service level constraints. Exact methods are only computationally feasible for very small problems, hence we have developed fast but highly accurate approximation methods. In an actual case study, our results show that integrated planning can achieve an overall cost reduction of up to 27 % without sacrificing the offered service quality, when compared with the common practice solution used in companies. Combining our approach with smart sensor and condition monitoring data (Internet of Things) may further enhance asset availability and hence industrial production both in Qatar and in the Netherlands.

Maintenance logistics has received considerable attention in recent decades owing firstly to the significant investments associated with capital-intensive assets, which in turn require a high operational availability, and secondly to

\$100,000 per hour. Consequently, unplanned downtime should be prevented as much as possible, for example, by exploiting advanced condition monitoring techniques and preventive maintenance policies, and if they

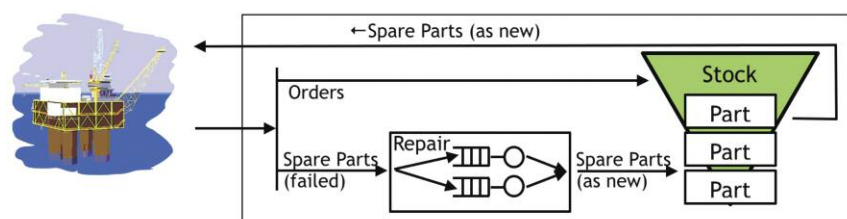


Figure 1: In the MLOG project, we are developing fast approximation algorithms to optimize service supply chains, while reducing the overall costs with 27 % in an actual case study.

the need to prevent environmental damage – for example, the BP accident in 2010 in the Gulf of Mexico - or safety incidents – for example in medical equipment and aircraft. Unplanned downtime of advanced capital equipment can be extremely expensive; for an average aircraft it is estimated at some \$10,000 per hour and for a high-tech lithography system in the semiconductor industry it may amount up to

occur, they should be kept as short as possible by using optimal corrective maintenance policies [1]. The latter implies that malfunctioning parts or components causing the system breakdown are immediately replaced by ready-for-use ones, since repair of the complete system on site induces unacceptable long downtimes. Typically, a system failure induces a set of actions as depicted in Figure 1.

The availability of resources needed for repair (spare parts, service engineers, and tools) in fact defines the operational availability of the complete asset. However, both spare parts and skilled service engineers often require high investments (parts worth \$50,000 are no exception for capital-intensive assets), hence there is a trade-off between resource investments and service provided. Much research has been carried out on spare parts management see [2]. So far the planning of resources has largely been performed independently (per resource) while their simultaneous availability is essential to minimize downtimes.

Contribution

As part of this project, we have been studying a service region in which a local spare parts inventory supplies different types of parts. Failures occur randomly and are often due to one malfunctioning part that needs replacement. In addition, a skilled service engineer is needed to complete the repair and replace the defective part. Malfunctioning parts are repaired off-line and subsequently stocked for future use. The focus here is on the integrated, multi-resource approach, for which different service policies are available: (i) complete backlog in case of unavailability of either parts or engineers, (ii) an emergency service fulfillment from an external source in case of unavailabil-

ity of either parts or engineers, (iii) and the heterogeneous policy with backlogging for one resource and emergency for the other.

The most realistic heterogeneous policy would involve having parts supplied by an emergency service and engineers backlogging. This is due to the long spare parts replenishment time that is often encountered compared with the engineers' service time. To evaluate such a heterogeneous policy, we have developed accurate methods using Mean Value Analysis and Laplace Transform techniques that can handle practical problems with a high number of different types of parts [3]. Our methods can tackle these problems quickly as opposed to the standard Matrix-Geometric approach, which is only computationally feasible for very small problems. This is due to the detailed description of the system state needed in the standard approach. In addition, we also consider the overall logistic support system optimization, i.e., we determine optimal stock levels and service engineer crew size, such that the average total costs (including spare parts holding costs, hiring cost of service engineers, and emergency costs) are minimized subject to pre-specified service level constraints. For real problems with high number of part types, our methods yield solutions very fast while the total cost error is negligible when compared with an exact method

(only verifiable for small problems). The optimization algorithm demonstrated an overall cost reduction of 27% in an actual case study, when compared with the separated optimization, which is common practice in companies. Future research may include advance information based on condition monitoring data (smart sensors, IoT) to move to preventive maintenance, thereby further increasing asset productivity.

MLOG was awarded by the NPRP program, 7th cycle in 2014, and funded by the Qatar National Research Foundation for a period of three years, starting from January 2015.

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- [2] C. C. Sherbrooke: "Optimal inventory modeling of systems: multi-echelon techniques", Springer, 2004.
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Utilising the Uniqueness of Operation Days to better Fulfil Customer Requirements

by Sara Gestrelus

No two days are exactly the same on the Swedish railways. Despite this, most trains are granted only one train path that they are supposed to use every day of operation. Restricting each train to a single train path wastes infrastructure capacity and prevents train operators from getting the capacity they require. In a project funded by the Swedish Transport Administration, SICS Swedish ICT used optimization to plan for each operation day individually. The results show a major improvement in customer requirement fulfillment.

Train operators apply for track capacity in September each year, and it is the Transport Administration's job to combine the trains in the applications into a yearly timetable. In order to make the timetable problem manageable for manual planning, only one train path is generally constructed for

each train. All conflicts that this train faces with some regularity should be resolved in this one train path. However, the traffic pattern is different on different days, and to make this one train path conflict-free for all days the planner is forced to include extra time both for conflicts that occur,

for example, solely on Mondays, and also for conflicts that occur solely on Wednesdays, even if including extra time only once would have been enough. This wastes capacity and results in the train path having unnecessary stops and time supplements on the day of operation.